A conclusion similar to that reached by Matthew (6) in connection with a study of the evolution of land vertebrates may be drawn. It would seem to be unnecessary to postulate any profound change in the existing distribution of land masses to account for the present distribution of *Scirpus* between the two hemispheres. To assume change in climate is probably unnecessary since species are apparently being interchanged between North and South America at the present time, but a more uniform climate would facilitate this process. Such changes as did occur in the past certainly have had their effect on the history of the species concerned, but, apparently, any theory involving cataclysmic phenomena is not essential to account for the migrations of North and South American species of this genus.

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THE PROBLEM OF LIFE ZONES ON MOUNT SHASTA, CALIFORNIA

William Bridge Cooke

In 1898 a party led by Dr. C. Hart Merriam made a biological survey of Mount Shasta. In the report (6) published in 1899 Dr. Merriam defined the several life zones he found on the mountain on the basis of his earlier discussion of North American life and crop zones (5). The writer, after four years of study, has come to the conclusion that two of the three zones must be revised or clarified (or, as to one of them, completely eliminated) in order that the casual visitor and future worker may be less confused as to the boundaries of the upper zones. The present paper is an

attempt to point out some of the problems encountered and the conclusions resulting from a study of these problems.

The Upper Sonoran zone (in Merriam's terminology) occurs within sight of the mountain in Shasta Valley to the north, in Sacramento Valley to the south, and in the valleys of the Great Basin areas to the east, for example, the areas found in the vicinity of the Modoc Lava Beds National Monument (1). On Mount Shasta this zone does not occur above 4000 feet, the contour line which has been chosen as the lower limit of the area covered by this study.

The Transition zone is clearly differentiated on Mount Shasta. Where the base of the mountain extends down to 4000 feet this zone can be divided into two minor belts. The lower of these may be called the Chaparral Belt. The term refers here to a Transition zone chaparral, a broader interpretation than that of Cooper (2). Wherever the Transition zone forest has been disturbed on the mountain a dense growth of chaparral has taken its place and to a certain extent has invaded the remaining forested portions. Before the Shasta National Forest was established, great areas of timber were logged. Fire contributed to the further destruction of whatever forest might have been left so that the former forest composition must be reconstructed by study of the accounts of early travelers and from isolated trees and small groves throughout the area. The zone is dominated by *Arctostaphylos patula* and *Ceanothus velutinus*. Additional shrubs include: *Ceanothus cordulatus, C. divaricatus, C. prostratus, Castanopsis sempervirens, C. chrysophylla, Purshia tridentata, Pachystima myrsinites* and others listed in Table 1.

Above the chaparral belt there is a narrow belt of forest, typical of the normal Sierran Transition zone except that on the northeast quarter of the mountain there occurs a large stand of *Pinus contorta* var. *Murrayana* which almost completely replaces the normal forest association. The normal forest, except where it is invaded by the chaparral, includes the following coniferous species: *Pinus ponderosa, P. Lambertiana, P. monticola, P. attenuata, P. contorta* var. *Murrayana, Abies concolor, A. magnifica* var. *shastensis, Libocedrus decurrens* and *Pseudotsuga taxifolia*. Various species of deciduous trees and shrubs which form lower stories in this forest are listed in Table 1.

Above the Transition zone forest is the Canadian zone as interpreted by Merriam. Except on the northeast side it is almost wholly composed of *Abies magnifica* var. *shastensis* which covers an altitudinal belt of from 500 to 1500 feet around the mountain. At the head of Panther Creek, and between the east side of Gray Butte and the west side of Mud Creek Canyon, and at one or two other small isolated stations, *Tsuga Mertensiana* enters this forest. Locally there may be colonies of from a few hemlocks in the fir forest to a few firs in the hemlock forest. In the vicinity of upper

TABLE 1

Species of woody plants occurring in the Transition Chaparral (Ch), Transition Forest (T), Canadian (Ca) and Hudsonian (H) zones on Mount Shasta, compared with the Zone Indicators of Hall and Grinnell (3) for Upper Sonoran (US), Transition (T), Canadian (Ca) and Hudsonian (H) zones.

Species	Position on Shasta	Zone Indicator
Abies concolor	ChTCa	T
Abies magnifica var. shastensis	TCaH	Ca
Acer glabrum	TCa	Ca
Alnus viridis var. sinuata	CaH	
Amelanchier alnifolia	ChT	
Arctostaphylos nevadensis	TCaH	Ca
Arctostaphylos patula	ChTCa	T
Castanopsis chrysophylla	ChT	T
Castanopsis sempervirens	ChTCaH	Ca
Ceanothus cordulatus	Ch	
Ceanothus divaricatus	Ch	US
Ceanothus prostratus	ChT	T
Ceanothus velutinus	ChTCa	T
Cercocarpus ledifolius	CaH	
Chamaebatiaria millefolium	Ca	
Chrysothamnus Bloomeri var. angustatus	ChTCaH	
Chrysothamnus nauseosus var. occidentalis	Ch	
Cornus californica	T	
Cornus Nuttallii	Ch	T
Juniperus communis var. montana	H	
Kalmia polifolia	CaH	H
Libocedrus decurrens	ChT	T
Lutkea pectinata	CaH	
Pachystima myrsinites	Ch	
Phyllodoce empetriformis	CaH	
Pinus albicaulis	CaH	H
Pinus attenuata	ChT	US
Pinus contorta var. Murrayana	TCa	Ca
Pinus Lambertiana	ChT	T
Pinus monticola	TCa	Ca
Pinus ponderosa	ChT	T
Pinus ponderosa var. Jeffreyi	TCa	Ca
Populus tremuloides	TH	Ca
Populus trichocarpa	T	
Prunus demisa	Ch	T
Prunus emarginata	ChTCa	
Prunus subcordata	Ch	
Pseudotsuga taxifolia	ChT	T
Purshia tridentata	ChT	US
Ribes cereum	ChTCaH	
Ribes divaricatum	Ch	
Ribes nevadense	T	
Ribes Roezlii	ChTCa	
Ribes viscosissimum	ChTCa	
Salix Scouleriana	ChTCa	
Sambucus caerulea	ChT	
Sambucus racemosa	Ca	
Tsuga Mertensiana	CaH	H
Vaccinium caespitosum	Ca	
Vaccinium occidentale	TCa	Ca

TABLE 2

Species of herbs occurring in the Canadian (Ca), Hudsonian (H), and Subalpine (A) zones on Mount Shasta compared with zonal distribution of previous records (Arctic-Alpine, AA), and with the Hall and Grinnell Indicator lists.

Species	Position on Shasta	Reported position	Indicator of Zone
Achillea lanulosa var. alpicola	H	AA	
Carex Breweri	CaHA	AA	AA
Carex phaeocephala	A		
Dicentra uniflora	CaH	AA	
Draba Breweri	HA	AA	AA
Erigeron compositus var. trifidus	HA	AA	H
Hulsea nana	HA	AA	AA
Juncus Parryi	CaHA	AA	
Lewisia pygmaea	H		AA
Lewisia triphylla	H	AA	Ca
Oxyria digyna	CaHA	AA	AA
Penstemon Menziesii var. Davidsonii	CaHA	HAA	AA
Phacelia frigida	HA	AA	
Poa Pringlei	A		
Polemonium shastense	HA	AA	
Polygonum minimum	H		
Polygonum Parryi	H		
Polygonum shastense	CaHA	HA	H
Potentilla flabellifolia	H	H	Ca
Potentilla Sibbaldii	H	H	AA
Saxifraga Tolmiei	HA	AA	AA
Silene Watsonii	HA	AA	

Squaw Valley Creek hemlock makes up nearly seventy-five per cent of the forest cover. In the middle and lower portions of the zone a few individuals of *Pinus monticola* may be scattered among the firs. However, along the west bank of Mud Creek Canyon this species is represented by scattered individuals from the upper limit of erect firs to the middle of the Transition zone forest. One of the interesting features of this zone is the forest on the northeast quarter where the Canadian zone may not exist at all, or where it may be considered as replacing the Transition zone forest. Here species of the Transition zone, including *Pinus ponderosa* (possibly the variety *Jeffreyi*) and *Abies concolor* mingle in a mixed forest with (a) species from the Hudsonian zone, including *Pinus albicaulis* and *Juniperus communis* var. *montana;* (b) species from the Canadian zone, including *Abies magnifica* var. *shastensis* and *Pinus monticola;* and (c) the anomalous species (at least on Mount Shasta) *Pinus contorta* var. *Murrayana, Castanopsis sempervirens* and *Ribes cereum.*

At the borders of the Canadian zone are broad areas transitional to the Hudsonian zone above and the Transition zone below. The belt on the lower side includes *Abies concolor, A. magnifica* var. *shastensis* and *Pinus ponderosa* var. *Jeffreyi.* In a swamp at Wagon Camp *Vaccinium occidentale* is dominant. The belt on the upper

side includes semierect or dwarfed specimens of *Pinus albicaulis, Abies magnifica* var. *shastensis* and *Tsuga Mertensiana.* These transitional belts could be labeled with the combined names of their commoner species: "Mixed Fir-Jeffrey Pine belt" and "Pine-Fir-Hemlock belt." In addition to the coniferous trees which have been mentioned as components of the Canadian zone, a number of broadleaf trees and shrubs occur in the area. In the dry forests are *Ribes cereum, R. viscosissimum, Cercocarpus ledifolius* and *Populus tremuloides;* while in the meadows and spring areas occur *Phyllodoce empetriformis, Kalmia polifolia, Lutkea pectinata* and *Alnus viridis* var. *sinuata* in addition to others listed in Table 1. Arms of the previously mentioned chaparral extend into this zone.

It is above the Canadian zone that difficulties are encountered. These difficulties lie in the interpretation of timberline, in the distinction between the Canadian and Hudsonian zones and in the presence or absence of an Arctic-Alpine zone.

Merriam considered an Arctic-Alpine zone present on the mountain. He thought that timberline coincided with the highest limits of *Pinus albicaulis,* even though at its highest limits all individuals are reduced to mats of from a few inches to a foot or more in height. With this interpretation, timberline is the upper limit of the Hudsonian zone, which is almost exclusively made up of, and is characterized by, *Pinus albicaulis.* Timberline, then, according to Merriam, divides the Arctic-Alpine from the Hudsonian zone. Thus timberline extends up most ridges on the mountain to heights of from 9000 to 9500 feet, with occasional arms up to 10,000 feet. The basins formed by Post-Pleistocene glacial cirques, and by moraine materials at about 8000 to 8500 feet would have a much lower timberline, perhaps between 8000 and 8500 feet, depending on the more or less strict application of the term to isolated stands of pines on the faces of minor ridges (with barren gulleys between and below them) and to the presence or absence of trees of any height on the flats below these ridges. The Arctic-Alpine zone, then, would include the areas on ridges on which a fair stand of dwarf pine occurs and which lie in the shade most of the day and thus are considerably cooler in climate. These cooler ridge slopes are on the south and east sides of the ridges and hold snow banks longer, at a lower elevation, than other more exposed areas. In one place, at least, on the north side of Red Butte, there is a small timberline area with a growth of plants above it. This small community was included by Merriam in the Arctic-Alpine zone because of its more severe climate as indicated by an association of plants which includes: *Polemonium shastense, Silene Watsonii, Oxyria digyna, Saxifraga Tolmiei* and others. However, it was admitted that on top of the Butte, several hundred feet above this colony, there is a fairly large stand of Hudsonian zone timber. A number of similar "Arctic-Alpine" associations occur below timberline as conceived

by Merriam, some of which grow in climatically restricted areas such as this, while others occur in apparently normal Hudsonian zone climate.

There are other conceptions of what constitutes timberline. We are referring here, of course, to alpine timberline rather than to sea-level poleward timberline, or to those desert or grassland associations on the borders of which tree species drop out in transition belts. United States forest rangers of the Shasta National Forest consider timberline as the upper altitudinal limit of upright tree growth. This is an economic interpretation of the word. In this sense the line or belt between the Canadian and Hudsonian zones is timberline. According to Hopkins (4, 7): "Climatic timberline may be defined as the poleward sea-level or alpine altitude limit of upright growth of tree species, under otherwise favorable conditions, as distinguished from dwarf or prostrate forms of the same species, as controlled by the climatic elements of temperature, wind, snow, ice, etc.; and also as distinguished from limits of tree growth due to the absence of suitable soil, moisture, or the presence of local glaciers." In the sense of Hopkins, then, Merriam's Shasta Hudsonian zone would occur above climatic timberline (which coincides with the economic timberline of the forest ranger).

Proceeding to the problem of the Merriam Arctic-Alpine zone on Mount Shasta, it should be noted that the term "Arctic-Alpine" is misleading. Conditions of growth in the arctic circle are different from those in an alpine habitat where the air pressure is lower, the proportion of daylight nearly the same as that normal to the latitude under consideration and temperature change during the growing season more frequent. Since these factors affect food production and other physiological processes of the vegetation the Arctic zone should be differentiated from the Alpine. On Mount Shasta, then, the vegetation may be considered alpine rather than arctic and according to either Merriam or Hopkins the zone would occur above the limits of tree growth. This zone, therefore, if recognized on Mount Shasta, is characterized purely by herbaceous plants.

The Alpine zone may be interpreted in terms of associations or an association of plants, in which sense Merriam occasionally used the term in discussing the flora of the mountain. On Mount Shasta a number of species reputedly occur (6) above tree-line. These include: *Polemonium shastense, Oxyria digyna, Phacelia frigida, Silene Watsonii, Draba Breweri, Carex Breweri, Juncus Parryi, Dicentra uniflora, Saxifraga Tolmiei* and others. However, all these species have been discovered below the upper limits of tree growth in various habitats such as draws, flats, gulleys and ridges which occur in Merriam's Hudsonian zone; all these species have been observed in association with *Pinus albicaulis*. The only species yet known which occur above timberline as delimited by Merriam and

not also below it are *Carex phaeocephala* and *Poa Pringlei* both of which were collected in 1939 along the Summit Trail in an area which Merriam would have called truly alpine since it lies at between 9000 and 10,000 feet, in the cirque in question fully 500 to 1000 feet above the highest limits of his interpretation of timberline. Merriam had no temperature records upon which to base his Shasta Alpine zone. He therefore based it upon the association of plants found in an area which should have certain theoretical temperatures. But is this association truly alpine when all but two of its constituents (these two unreported until recently) are found in the Hudsonian zone?

Hopkins defines the bioclimatic zones in three major zones and a number of minor zones. The three major zones include: I. "North and south, polar or arctic and alpine, humid or arid major regions of the Frigid Zone." II. "North and South, temperate or intermediate latitudes or altitudes, major arid and humid regions of the Temperate Zone." III. "Tropical and equatorial low and high land, humid and arid major regions of the tropical zone." Four groups of minor zones, of which group 4 is warmest, are described under Major zone I. Upper minor zone 4 is defined as "Arctic and alpine above and below perpetual ice and snow, lower transition or snow line zone." Under Major zone II, Hopkins describes seven groups of minor zones of which group "1" pertains to the present problem. Under "Upper minor zone 1" the following definition is listed: "High latitudes and altitudes, subarctic and alpine regions and areas above climatic timberline or its equivalent, 'timberline zone.'" "Lower minor zone 1" is "timberline."

Mount Shasta has no permanent snow line. The five glaciers which are still active are confined to areas above 10,000 feet and apparently have no immediate effect on the surrounding vegetation. In their vicinity the soil is too poor and the drainage too complete for an association of plants to survive even though no glacier occurred. The permanent snow fields on the mountain are small and scattered and have little effect on the minimal vegetation in their vicinity largely because they are above the areas where plant life, except lichens and algae, survives even sparsely.

From these considerations, an Alpine zone on Mount Shasta is not to be expected. Certainly if permanent snow lines do not exist on the mountain, by definition, Major zone I is absent. The next zone is Major zone II, Upper minor 1. This is subalpine, and from areas of greater distribution of plants, might even be considered upper Hudsonian. However, the finer threads cannot be split until more definite statistics are available for the climate of the mountain, especially in its upper regions, throughout the year.

Foster, Warren County, Ohio,
December, 1939.

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A NEW SPECIES OF LOTUS FROM THE MOUNT HAMILTON RANGE, CALIFORNIA

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Lotus rubriflorus sp. nov. Herba annua albosericea, pilis longis; caules 1–5 aliquando decumbentes, 3–10 cm. longi; folia 10–16 mm. longa exstipulata, 4-foliolata imparipinnata, rachibus complanatis, foliolis lanceolatis acutis, 2–11 mm. longis; flores solitarii axillares subsessiles, 6–7 mm. longi; calyx dense pilosus lobis linearibus acuminatis, 4–5 mm. longis, corollam aequantibus; petala rubra in aetate caerulescentia; legumina pilosa, oblonga dehiscentia, 8–9 mm. longa.

Slender annual; stems 1–5 (mostly 2–4) from base, 3–10 (mostly 4–8) cm. long, usually somewhat decumbent; herbage pilose throughout with long, white, silky, somewhat appressed or spreading hairs; leaves 10–16 mm. long, exstipulate, imparipinnate; rachis flattened, about 1 mm. broad; leaflets 4, two appearing terminal, the remaining two on one side of the rachis, 2–11 mm. long, subsessile, lanceolate, acute, terminal leaflets often slightly falcate; flowers 6–7 mm. long, solitary, axillary, subsessile, usually bracteate; calyx 6–7 mm. long, densely pilose; tube 1.5–2 mm. long; lobes linear, acuminate, 4–5 mm. long, equalling corolla; petals glabrous, clear bright pinkish red (aster purple[1]), fading bluish, claws white, banner 5 mm. long; wings shorter than or about equalling keel, posterior dorsal lobes large and very narrowly margined with white; keel 5 mm. long, apex somewhat pointed, body very narrowly margined with white dorsally and posteriorly; ovary densely pilose, dorsal margin straight, ventral margin curved; style pilose below, glabrous above, curved near base; legumes pilose, 8–9 mm. long, 2.5 mm. wide, oblong, stramineous; seeds 2–4, 2 mm. long, 2 mm. wide, irregularly lens

[1] Ridgway, R. Color standards and color nomenclature, plate 12. 1912.